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Flower And Cone Damage By The Spruce Budworm

Spruce budworm feeding is greatly reducing cone production throughout the outbreak areas of central and eastern Canada. In the spring, second-instar larvae leave the overwintering sites and feed on the buds, needles, and flowers of the host. Larval emergence is often closely synchronized with the appearance of flowers and the succulent flowers are more readily fed on than the old foliage or buds. Several days to about 2 weeks after the flowers develop, vegetative buds burst and new needles become available to the larvae. Both male (pollen) and female (ovulate) flowers of all host tree species are consumed. On balsam fir, the larvae feed at the base of the ovulate flowers and commonly kill them by girdling the axis. On black spruce, larvae often consume whole flowers. Only about 10% of the ovulate flowers on balsam fir remain undamaged and develop into cones during a year in which trees are severely defoliated. The budworm is even more destructive on black spruce trees. Virtually all cone flowers are destroyed when only a small larval population is present.

Flowers provide a rich source of the nutrients required for budworm development. Early instar larval populations feeding on flowers develop faster and tend to have higher survival rates than those feeding on vegetative structures. These early advantages can result in higher than average, late larval survival and a subsequent population increase. However, the advantages of feeding on flowers are only available at the initial stage of a developing infestation. During an outbreak, the production of flowers is greatly reduced. Budworm feeding decreases the size and number of shoots upon which the reproductive structures occur in a tree. These decreases become more pronounced as the severity and number of years of damage increases. Reproductive bud production on balsam fir in the year following damage is reduced by 50% on trees severely defoliated for 1 year and by 75% on trees severely defoliated for 2 or more years. On black spruce, pronounced decreases in reproductive bud production occur after only minor defoliation for 1 year.

Immature cones are also susceptible to budworm damage and may be entirely consumed. If only damaged, they may continue their development but their surfaces will become distorted and dented. These damaged cones are more susceptible than healthy cones to renewed budworm damage and to subsequent damage by other cone insect pests. The spaces between cones in a cluster and the cavities in the irregular surface of single cones form protected resting places for larvae. All cones near such resting places are likely to be damaged because budworm larvae will continue to feed on cone tissue until they pupate. In black spruce and balsam fir stands that are severely defoliated, very few if any cones reach maturity. Usually, most surviving cones have been damaged.

Decreased cone production reduces the seed available for the natural rejuvenation of stands when they are harvested or die unharvested as a result of budworm attack. Also, procurement of the seed required for tree nursery and silvicultural programs has become difficult and expensive.

At present, government and industry research experience is not adequate to suggest a reliable prescription for the protection of cone crops from the spruce budworm. More research is required to identify a suitable insecticide and to determine the best methods, volumes, and timing for spray applications. Control tactics to protect spruce seed orchards from several lepidopterous pests, including the spruce budworm, are being given special consideration. Among these pests, the spruce coneworm (*Dioryctria reniculelloides* [Mut. & Mun.]) is the most difficult to kill with chemicals. Any procedure that successfully controls the coneworm will very likely also be successful against the budworm.

Hugh D. Schooley — Newfoundland Forest Research
Centre
St. John's, Nfld.

The Case Of The Missing Larvae

Managing insect populations without pesticides is a challenge to researchers in the 1980s. At the Pacific Northwest Forest and Range Experiment Station, entomologists Robert Campbell and Torolf Torgersen and ecologist Roy Beckwith of the USDA Forest Service are working on such a project. They are learning more about the effects of predators on the larval populations of the western spruce budworm (*Choristoneura occidentalis* Free.) and other defoliators.

Studies were conducted at several sites in the Methow and Okanogan river valleys of north-central Washington with interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca* [Beissn.] Franco) as the principal host species.

The methodology used for calculating survival rates of both late instars and pupae previously had been based on the sampling and life table development for the spruce budworm in the classic papers by Morris (Can. J. Zool. 33:225, 1955) and Morris and Miller (Can. J. Zool. 32:283, 1954). In these and other publications, the investigators recognized that entire populations of budworm pupae could be removed by predators but these losses would have been ignored and classified as missing larvae. Thus, the standard methodology for calculating survival rates led to underestimating larval survival and overestimating pupal survival and predation of large larvae, while ignoring predation among pupae.

The scientists believed that the results based on these prior compilations and analyses of life tables for both the spruce budworm (*C. fumiferana* [Clem.]) and western spruce budworm may have included spurious and misleading conclusions. To test this, researchers began monitoring the insect populations at both high and low densities on the experimental sites. They found predation was most effective in controlling populations of forest defoliators at low densities. The added discovery of high predation rates among dense populations surprised the researchers, sparking their curiosity to find out the identity of the predators.

The researchers conducted a set of tests to determine which predators and/or organisms were most important. In one case, many of the pupae were removed by ants (R.W. Campbell and T.R. Torgersen, unpublished data on file at Pacific Northwest Forest and Range Experiment Station, Portland, OR). In other cases, birds were responsible for sizable losses of larvae. Both these organisms had major impacts on the insect populations.

In 1979, the researchers found that up to 92 percent of the western spruce budworm pupae disappeared. This pupal loss would have been classified as larval mortality by the methods heretofore used, thus underestimating larval survival and overestimating pupal survival and predation of large larvae.

To measure the impact of ants, the scientists used Tanglefoot, a sticky material wrapped around the tree to trap insects climbing up the trees. Ant predation was compared on trees utilizing Tanglefoot with that on control trees. In some areas, the scientists found that ant predation had serious effects; research projects are continuing on this subject.

To measure the effect of birds, the scientists assembled and erected cages large enough to enclose each study tree. They assembled 32 cages with plastic pipe covered with plastic-mesh garden net. The netting excluded birds but permitted free access of insect predators and parasites. Drop cloths, placed at the bases of the trees, caught insects falling to the forest floor, such as dead budworm larvae or parasites that emerged from their host and dropped from the tree.

Additional studies should resolve many questions about the impacts that birds, ants, and other organisms have on spruce budworm populations. Future research may also help define predation impacts for other insect populations.

Kathleen Kirkland — Pacific Northwest Forest and Range Experiment Station
Portland, OR

Work Conference Held At Banff

The 32nd annual Western Forest Insect Work Conference was held March 2-4, 1981, at Banff, Alta., with about 120 Canadian and American delegates in attendance.

The theme was "Challenges for the 80s" and there were four plenary panels:

"What are some of the research challenges ahead?"

"What are the land manager's needs?"

"The Mount St. Helens eruptions and their significance to forest entomology."

"Are we making any progress?"

Five concurrent workshops were held during the conference.

Delegates agreed upon a number of items: entomologists must become better integrated into the forestry community; integrated pest management (IPM) must become more a part of intensive forest management; pest managers must sell their products through public education programs; research agencies should improve their performances in technology transfer. Indeed, delegates felt, research proposals should include a technology transfer plan.

The conference discussed the need for entomologists to improve the ability to predict. "Best guess" outcomes are required, it was agreed, and entomologists should "Behold the turtle — he goes nowhere unless he sticks his neck out."

Jim Cayford, acting Director General of Research and Technical Services, Canadian Forestry Service, delivered the keynote address, "Forest Entomology Challenges for the 80s," in which he offered nine challenges:

1. Forest entomologists must pay increasingly more attention to their practicing clients, the forest land managers.
2. New biological techniques for forest pest management must be placed in the hands of land managers.
3. The human health aspects of forest management must be addressed to the satisfaction of the bystander.
4. Improved strategies are required for large-scale pesticide application.
5. Interdisciplinary approaches are required to address the major forest insect problems.
6. Improved damage appraisal systems are required to quantify losses from forest pests.
7. The need to apply the knowledge that we already have is pressing.
8. There is a need to recruit younger forest entomologists to replace older members of the profession who are not far from retirement.
9. Preventive techniques of pest management are required as alternatives to direct control measures.

Most of the speaker's comments can be applied directly to the CANUSA programs.

Decision-Support System Workshop

A workshop on the developing spruce budworm decision-support system was held in Moscow, ID, March 24-26, under the sponsorship of CANUSA-West.

From the beginning, forest managers have been helpful to the Program through Working Group meetings, and their contributions are reflected in the schedules that guide Program Activities. The Moscow meeting provided a forum for dialogue between managers and researchers on the kinds of decisions that must be made in dealing with budworm, the criteria managers and planners use in making those decisions, spatial and temporal constraints, and what components of a decision-support system are currently available — or ought to be — by the end of the Program.

Small-group discussions were led by a user group representative assisted by a CANUSA staffer serving as recorder. Groups were asked to address a series of questions on how decisions are made, relative to both forest and pest-management planning and operations. Groups exchanged brief summaries after each session, and all participants joined in discussing, dissecting, and synthesizing the information in several plenary sessions.

Discussion leaders were Bill Ciesla, Forest Pest Management (FPM), Methods Application Group, Davis, CA; Larry Freeman, FPM, Region 5, San Francisco, CA; Ladd Livingston, Idaho Department of Forestry, Coeur d'Alene; Galen Trostle, FPM, Portland, OR, (retired); Dave Baumgartner, Washington State Extension Forester, Pullman; Jim Opdycke, Okanogan and Wenatchee National Forests, Washington and Dick Shaffer, Timber Management (TM), Region 3, Albuquerque, NM.

Recorders were Donn Cahill, FPM, Region 4, Boise, ID; Dan Twardus, FPM, Region 6, Portland, OR; Cathy Stein, FPM, Region 3, Albuquerque; Bill Wulf, TM, Region 1, Missoula, MO; Peter Mika, University of Idaho, Moscow; Lorna Youngs, Oregon State University, Corvallis; and Nilima Srivastava, CANUSA-West, Corvallis, OR.

Resource personnel available to assist in the discussions included Program Manager Ron Stark, Research Coordinator Jim Colbert, Applications Coordinator Tom Flavell, Editor Martha Brookes, and Tom Bible, Oregon State University; Bob Campbell, PNW, Corvallis; Al Stage, Intermountain Forest and Range Experiment Station (INT), Moscow; and Nick Croodston, INT and University of Idaho, Moscow.

CANUSA Stars At Hazard-Rating Symposium

By early this summer, the proceedings of last July's hazard-rating symposium in Athens, GA will be in print. CANUSA Program investigators delivered 7 of the 20 talks, and Applications Coordinator Bob Talerico evaluated the entire program as reviewer.

Fred Knight, Director of the School of Forest Resources at the University of Maine, gave the keynote address. John Witter and Thomas Mog of the University of Michigan presented "An Integrated Approach for

Assessing Spruce Budworm Damage and Developing a Hazard-Rating System and Stand Models for Spruce-Fir Stands in Michigan's Upper Peninsula." The Witter-Mog team, funded by CANUSA-East, is currently in the 3rd year of a planned 5-year effort.

Hugh Schooley, a cooperator from the Canadian Forestry Service in Newfoundland, discussed his hazard-rating system for balsam woolly aphid damage in that province. Representing CANUSA-West were Al Stage and David Hamilton, Jr., who spoke on "Sampling and Analytical Methods for Developing Risk-Rating Systems for Forest Pests."

A group of USDA Forest Service investigators from the West — Malcolm Furniss, Ladd Livingston, and Mark McGregor — discussed their stand susceptibility classification for Douglas-fir beetle. The team of Peter Mika, Bob Heller, and Karel Stoszek, of Moscow, ID, presented a paper entitled "Applications of Models Developed to Risk Rate Forest Sites and Stands to Douglas-fir Tussock Moth Defoliations."

The Lake States CANUSA experimenters were represented by Harold Batzer and Arthur Hastings, of the USDA Forest Service. They spoke on rating spruce-fir stands for spruce budworm vulnerability in Minnesota.

General Technical Report WO-27, titled "Hazard-Rating Systems in Forest Insect Pest Management: Symposium Proceedings," will be available on request from: Information and Publications, USDA Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

EMOFICO Restructures

A meeting of the Committee for Environmental Monitoring of Forest Insect Control Operations (EMOFICO) was held in Fredericton, N.B., on March 10, 1981. It was attended by about 30 people, representing a wide variety of federal and provincial government groups, as well as universities and consulting firms. One of the purposes of this meeting was to discuss the future of EMOFICO that has been uncertain since I.W. Varty left his post as chairman August 31, 1980. Based on the terms of reference in the 1978-79 report, the following reasons were put forward for EMOFICO's future existence:

1. To promote the coordination of research on pesticide accountancy and monitoring of ecological effects of forest spraying operations.
2. To provide broad information to the public and governments on such effects and accountancy.
3. To provide, upon request, specific and scientific information to government agencies responsible for forest protection and environmental safety.
4. To provide technical advice to forest spray operators, with a view to enhancing environmental safety.

5. To identify environmental risk and benefits of insecticide tactics and strategy.
6. To review the adequacy of knowledge, identify gaps, and recommend appropriate action in monitoring and research.
7. To present an annual public report assessing annual and long-term effects of spray operations on the environment.

EMOFICO provides an important input to coordination of research and monitoring and development of forestry and spraying policies used by Environment New Brunswick, the Pesticides Advisory Board, Forest Protection Limited, and the provincial Department of Natural Resources, as well as federal agencies. It is also a valuable source of public information.

Dave Besner of Environment New Brunswick (ENB) is the interim chairman. Also, ENB has agreed to provide a secretariat for EMOFICO and the chairman, and to assist in writing the annual report. Under the new structure, it was agreed that the chairman would be elected for a 2-year period. Although there was a general agreement that the chairman should be selected from among the research scientists, it was agreed that the task would be too burdensome for someone who was conducting full-time research. The criteria for a chairman were described as follows: 1) have the ability to bring the group to a consensus; 2) have the ability to deal with the media; 3) have the time for the duties of the chairman; 4) be a resident of New Brunswick; 5) have a good overall knowledge of control impact.

Dr. Les Shemilt of McMaster University was approached by Dave Besner to consider the EMOFICO chairmanship. However, because of his location and over-commitment, he indicated that he could not take on new responsibilities during the next 8 months.

Committee members discussed Dr. Shemilt's proposed new structure based on the Joint Panel on Environmental Monitoring of Uranium Mining in Canada. This involves a two-tier membership, including active researchers and associate members (that is, those interested in research and impact), such as members of regulatory agencies. The group emphasizes exchange of information, informal program coordination with other groups to avoid duplication of effort, and public information. A more definite membership structure was thought to be needed, but members were concerned that rigidity or omission might result. The voluntary or cooperative quality of the association is greatly valued. The independence of EMOFICO from the agencies represented by its members is considered a priority.

The formation of a Steering Committee was discussed. It would include the EMOFICO Chairman, an ENB representative, and an independent individual. The Committee would edit the yearly report and govern its quality. If necessary, a peer review group could undertake the latter task. The Chairman would then be given more time for chairing meetings, sitting on the Steering Committee, and acting as spokesman to the media.

The need to achieve consensus is considered to be one of the major tasks of EMOFICO. By giving individual authors credits in the EMOFICO report and by giving the Steering Committee and ENB responsibility for producing the report, the problem has been alleviated. Researchers agreed that EMOFICO should coordinate its activities more with those of other monitoring agencies, in particular the Forest Pest Management Institute, Canadian Forestry Service.

The group agreed that a 1980 report should be issued as soon as possible, even though it may take an abbreviated form. EMOFICO members were asked to prepare summary statements for ENB by April 10, 1981. A more complete report may be issued at a later date.

Concern over the public's perception of EMOFICO's independence was expressed. The funding arrangement, the Chairman's association with a particular agency, and the difficulty of achieving consensus contribute to this problem.

In the future EMOFICO will be concerned with what chemicals to use, including new chemicals; changes in operational plans, such as the setback zone; and comments from specific groups, such as blueberry growers. Further attention needs to be directed towards long term effects, inhalation studies, ingestion studies, and indicator species identification and studies. In the light of present concerns, EMOFICO may, in the near future, expand its interests to include herbicide application.

Technology Transfer Committee Established In The East

CANUSA-East has convened a Technology Transfer Committee to aid Program Management in rapid implementation of new technology resulting from Program activities.

The committee will be composed of representatives of CANUSA-East Program Management and others, as follows:

Northeastern Area (State and Private Forestry) — Dan Kucera and Jerry O'Neal of Forest Pest Management and Clyde Hunt of Cooperative Forestry.

Northeastern Station, Planning and Applications — Ron Glass.

Region 9, Timber Management — Bob Blomquist.

The University of Maine — Tim O'Keefe.

The University of Minnesota — Steve Sinclair.

Janet Searcy, of the CANUSA Program Leader's Office in Washington, sits as an ex officio member.

The Committee will:

1. review the annual application plan and suggest revisions to activities,
2. review plans and progress reports of ongoing demonstration projects,

3. review CANUSA transition plans, and
4. suggest current opportunities for new demonstration projects or research results in need of application.

The Committee met for the first time March 24 in Broomall, PA, and future meetings will be scheduled on a regular basis.

Transition In 1980 — To What?

One does not travel long in CANUSA circles these days without hearing about "transition planning." What are we talking about? What does it mean to CANUSA investigators?

The Canada/United States Spruce Budworms Program is scheduled to terminate at the end of Fiscal Year 1983 (September 30, 1983, in the U.S. budget system). After that date, we expect that the special funds (accelerated program funds) now supporting about one-half the effort in the U.S. element of the joint program will no longer be available. Although some research and development on budworm and forest management could continue on regular (base) funds, competition for the attention of investigators now involved in the CANUSA Program will be great. The gypsy moth is poised for a southward expansion and the mountain pine beetle is rapidly turning the green forests of the Pacific Northwest, including British Columbia, to red, orange, brown, and gray.

The attention of CANUSA Program Management and investigators must not be diverted from achieving program objectives and providing the outputs projected in the activity schedule. But who will validate and prove the utility of the population dynamics and economic impact models and hazard-rating systems that can only be considered preliminary with so few years of observations? Who will maintain the several demonstration areas now in place to show the long-term benefits of new approaches to forest management in the presence of the spruce budworms? Will silvicultural and other long-term research continue in the context of budworm/forest management? Will research and development of new biological insecticides proceed to fruition, to provide safer means of budworm control in integrated pest management?

These are questions to be addressed by federal, state, and university administrators in the months ahead. CANUSA Program Management will assist by providing "best guesses" on what program products will be handed off to resource managers for implementation and what work will remain uncompleted at the end of the program.

The effects on the Canadian element of the CANUSA Program are likely to be less. North of the border, no special funds were provided. But since the budworms are no respecters of national boundaries, federal and provincial agencies, universities, and other cooperation elements are likely to continue their efforts against this pest far beyond 1983.

Non-Toxic Pest Control Products To Be Developed

An agreement was recently signed between the Canadian Forestry Service and Safer Agro Chem. Ltd. of Victoria, B.C., to fund research by that company for the development of new, safe, pest-control products from fatty acids and other bio-derivatives.

The contract, in the amount of \$60 400, was awarded through the federal government's Cooperative Project with Industry (COPI) program under which funds are made available for technology transfer from the government research facility to the industry.

The objective of this contract is to promote the commercialization of three different fatty acid products so that they become available in the market place for the general public.

The awarding of this contract is a direct result of the research being carried out at the Pacific Forest Research Centre by Dr. George Puritch on fatty acid salts.

Safer Agro Chem. Ltd., which has been marketing insecticidal soaps to control such pests as aphids, mealybugs, white flies, and spider mites for the past 3 years, is the only company in Canada and the United States developing and marketing bona fide fatty acid and insecticidal pesticides for both domestic and commercial use.

The new product line they will be researching will include ways and means of controlling mosses, algae, liverworts, and moulds and will be especially useful in nursery and home applications for such things as demossing roofs, lawns, and sidewalks.

The advantage of these products is that they are very low in toxicity to animals and man and are non-corrosive in nature," says Sergei Condrashoff, President of Safer Agro Chem. Ltd.

The company now generates work for six or seven local people, but the business could be expanded considerably once these new products have been developed and marketed.

"We are delighted that research initiated by the Canadian Forestry Service will have the opportunity to be developed by the private sector and will assist in the creation of new products and job opportunities," says Ross Macdonald, Director of the Pacific Forest Research Centre.

Spruce Budworm Information Is Solicited

Dan Jennings reports receipt of the literature citation section of the CFS brief to the Newfoundland Royal Commission on Forest Protection, as well as the personal life publication lists of Frank Webb and Wladimir Smirnoff. These lists contain a wealth of information and are valuable additions to the bibliography. Dan would welcome similar material from other scientists

who are working or have worked with spruce budworms. Address your correspondence to:

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USDA Building, University of Maine
Orono, ME 04469

Items From The Press

Spray program necessary to fight budworm damage — Steep slope harvesting, damaged tree salvaging, forest rehabilitation and a spray program are the weapons the province must use to combat spruce budworm damage according to Doug Kendrick, vice-president of administration at Bowaters in Corner Brook.

The province currently has a balance of about 25 million cords of wood, Kendrick said, and added that without a spray program combined with extensive silviculture, the balance could fall to 9 million cords in the 1990s.

Even with a spray program, the province will suffer a loss of wood to the budworm until around 1990, he said, when wood supplies should level off around 18 million cords.

Kendrick said that if the province takes a "no-spray" stance, the forest industry will be in grave danger as once the tree base is gone, it can't easily be built up again.

Steep slope harvesting could increase the province's wood supply by about 3 million cords, Kendrick said.

New technology developed in Scotland now enables this to be done. The trees on slopes are literally pulled down the slope by a chain boom.

Kendrick said wood that has been killed by the budworm must be harvested within five years of being infested, after which the tree has no commercial value.

Kendrick said there are 2,874 people employed with Bowaters in Corner Brook and added that in order to ensure their livelihood and that of other provincial forestry workers, the province must implement an intensive spray and silviculture program.

(The Evening Telegram — December 5, 1980)
St. John's, Nfld.

Matacil spraying to fight budworm is set by Peckford — St. John's (CP) — The Newfoundland Government, faced with the threatened loss of thousands of jobs in the forest industry, has decided to undertake a chemical spray program to fight the spruce budworm, Premier Brian Peckford announced yesterday.

About a million acres of productive forest land will be sprayed with Matacil in late June at a cost of about \$4.5 million, Mr. Peckford said. Two-thirds of the cost will be paid by the pulp and paper companies. The government will pay the rest.

The exact boundary lines of the areas to be sprayed will be announced soon, he said.

Mr. Peckford said the spray program was recommended by a royal commission on forest protection and management and it will be just one part of an integrated program to preserve and enhance the province's spruce and fir stands.

Mr. Peckford said that without spraying there would be serious shortages of wood for the forest industry within 10 years.

(Globe and Mail — February 17, 1981)
Toronto, Ont.

Spruce budworm biological control technology (B.t.) not yet perfected — *Bacillus thuringiensis*, better known as B.t., is currently the best alternative to the chemicals which have been used so far to control the spruce budworm.

Because of certain restrictions in its application and cost (4.4 times higher than chemical treatment), however, the Quebec Department of Energy and Resources does not plan a more intensive use of B.t. than in the past (i.e. 10 percent of the spraying program) for next year.

Jean-Guy Davidson, Director of the Entomology and Pathology Service of the Department of Energy and Resources, maintains that while research on this product must be continued, its use on a large-scale operational basis is not recommended at this time.

"It should also be pointed out," Mr Davidson added, "that no American State or Canadian Province has invested as much as the province of Quebec in the development of this biological agent."

Outside of the fact that it is definitely more expensive (\$5.1/ha vs \$22.6/ha) and must be sprayed in higher volume (two sprayings of 1.4 litres of chemicals per hectare vs one spraying of 7.0 litres/per hectare of B.t.), *Bacillus thuringiensis* presents considerable application problems and cannot be recommended for use everywhere because it is ineffective in severely infested areas.

In a report submitted to the Sixth International Congress of Agricultural Aviation, held in Turin, Italy, in September 1980, co-authors Louis Dorais and Michel Pelletier of the Quebec Department of Energy and Resources, and Wladimir Smirnoff of the Laurentian Forest Research Centre (LFRC), detailed the experiments conducted since 1971 by the department to develop a B.t. spraying technology.

The three authors reached the same conclusions. After recognizing B.t.'s chances of success as a spruce budworm control method, they also recognized the constraints inherent to this biological agent.

These constraints concern mainly the period of application and the budworm population level, weather conditions required to ensure an adequate deposit, the volume and dosage, the spraying system, and the spectrum of droplets.

(La terre de chez nous — Novembre 27, 1980)

Recent Publications

Two recent publications of the Forest Service's Expanded Southern Pine Beetle Research and Applications Program may be of special interest to CANUSA investigators.

USDA Agriculture Handbook 567 — "Loran-C Radio Navigation Systems as an Aid to Southern Pine Beetle Surveys" — describes the Loran-C equipment and explains how it works. This system, originally developed for marine navigation, can be successfully used to fly both aerial detection missions and resurveys to follow the progress of individual infestations. The brochure also illustrates a sample flight map with preflight data needed to initiate an aerial survey. Much of CANUSA-East investigation territory is shown on a map of the North-eastern U.S. Loran-C chain of transmitting stations.

Loran equipment varies in price from \$10 000 to \$30 000 depending upon accessory features, and can even be mounted in ground vehicles to help ground-check crews locate spots originally discovered from the air. The system can also help in aerial applications of pesticides and fertilizers, spray block design, search and rescue operations, and forest fire suppression.

Free copies can be ordered from: Information Center, USDA Forest Service, 1720 Peachtree Rd. N.W., Atlanta, GA 30367.

CANUSA investigators working with pheromones have probably already found that very little research has been done on exactly how pheromones are diffused, either over open ground or within a forest. Youhanna Fares, Peter J.H. Sharpe, and Charles Magnuson, of Texas A & M University, have addressed this subject in a symposium paper presented in 1980 at a southern pine beetle conference. "Pheromone Dispersion in a Forested Ecosystem" explores this complicated subject in detail. The article is included in USDA Technical Bulletin 1630, "Modeling Southern Pine Beetle Populations," which can be ordered from: Dr. Robert C. Thatcher, USDA Forest Service, Integrated Pest Management Program, 2500 Shreveport Highway, Pineville, LA 71360.

CANUSA's Information Coordinator, Janet Searcy, edited both publications during her tenure with the SPB program.

The Newfoundland Forest Research Centre has issued two reports. They are available from Nfld. FRC, P.O. Box 6028, St. John's, Nfld. A1C 5X8. They are:

1. "Survival and early growth of plantations on a drained fen in Central Newfoundland," Report N-X-178 by J. Richardson.

2. "Forestry industry statistics for Newfoundland," Report N-X-185 by J. Munro.

The Forest Pest Management Institute has published two new reports, "Preliminary field studies on the use of additives to improve deposition rate and efficacy of commercial formulations of *Bacillus thuringiensis* applied against the spruce budworm *Choristoneura fumiferana* (Lepidoptera: Tortricidae)" by O.N. Morris, M.J. Hildebrand and J.A. Armstrong (Report FPM-X-32) and "A survey of micro-organisms infecting a spruce budworm population" by J.M. Burke (Report FPM-X-37). They are available from FPMI, P.O. Box 490, Sault Ste. Marie, Ont. P6A 5M7.

Other publications available from various locations are: From the School of Forest Resources, Life Sciences and Agricultural Experiment Station, University of Maine, Orono.

"Wind damage in spruce-fir stands — A literature review with recommendations for harvesting methods," Miscellaneous Report No. 225 by Jonathan Falk.

From Forest Pest Management, State and Private Forestry, Southwestern Region, USDA Forest Service, 517 Gold Avenue SW, Albuquerque, NM 87102:

"Biological evaluation: western spruce budworm, Santa Fe National Forest and Jemez Indian Pueblo, New Mexico," Report R-3 81-5 by Iral R. Ragenovich.

From the USDA Forestry Service, Northeastern Area State and Private Forestry, 370 Reed Rd., Broomall, PA 19008:

"Proposed cooperative 5-year (1981-1985) spruce budworm management program for Maine."

Some other publications available are:

G.M. Howse and A.A. Harnden. 1980. "The 1979 spruce budworm situation in Ontario." O-X-310. 89 pp. Great Lakes Forest Research Centre, P.O. Box 490, Sault Ste. Marie, Ontario P6A 5M7.

George Puritch. "Soaps making a comeback on the pest control scene." Information Forestry, Pacific Forest Research Centre. Vol. 8 No. 1 Winter 1981. Editor, Elaine Teske, 506 West Burnside Road, Victoria, B.C. V8Z 1M5.

Thomas D. Smith et al. "Effects of six biocides on non-target soil meso-arthropods from pasture on Ste. Rosalie Clay Loam, St. Clet., Quebec." Proc. VII Internat. Soil Zool. Coll. August 1979, Syracuse, NY.

Special issue on the Spruce Budworm. The Maine Forest Review. Volume 13, 1980, A.D. Nutting Hall, University of Maine, Orono, ME 04469.

Steve Kleinschmidt, Gord Baskerville, and Dale Salomon. "Reduction of volume increment in fir-spruce stands due to defoliation by spruce budworm." Faculty of Forestry, University of New Brunswick, Fredericton, N.B. E3B 5P7

To insure that the NEWSLETTER does its part, we need your help. Additions and corrections to NEWSLETTER mailing lists should be sent to the Program Leaders. We will welcome your comments and questions on the content of CANUSA NEWSLETTERS, and especially your suggestions for future issues.

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